THE VELIGER
CMS, Inc., 2000

The Veliger 43(4):367–375 (October 2, 2000)

A New Species of Hydrobiid Snail of the Genus *Pyrgulopsis* from Northwestern Nevada

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Abstract. *Pyrgulopsis* ***bruesi*** new species, from northwest Nevada, differs from closely similar *P. augustae* on the basis of its higher-spired shell, larger penial filament, and more ventrally positioned seminal receptacle. This species is endemic to a thermal spring area in a small basin which was inundated by pluvial Lake Lahontan.

INTRODUCTION

Pyrgulopsis is the largest genus of freshwater mollusks in North America, with more than 130 species currently placed in this group (Hershler, 1994, 1995; Thompson, 1995; Hershler, 1998). Whereas these small, gill-breathing snails are broadly distributed in southern North America, the greatest diversity of *Pyrgulopsis* is in the Great Basin, a vast expanse of internal drainage lying between the Wasatch Front and Sierra Nevada of the western United States. Within this region most congeners are restricted to seeps and spring sources, while only a few species live in more integrated stream habitats. The isolated nature of these water bodies, reinforced by surrounding arid environments, has been highly conducive to differentiation of these poorly dispersing snails. Eighty species of *Pyrgulopsis* are now known from the Great Basin (Hershler & Sada, in press).

We recently collected biota at Fly Ranch Hot Springs (also known as Ward's Hot Springs; Garside & Schilling, 1979), north of Gerlach, Nevada. The small invertebrate assemblage of mollusks and crustaceans inhabiting thermal waters at this locality, which is part of a well-defined northeast-trending zone of thermal springs in northwest Nevada (Hose & Taylor, 1974:fig. 2), included a new species of *Pyrgulopsis,* which is described below. This new species is most similar morphologically to several congeners also living in the Great Basin of Nevada.

MATERIALS AND METHODS

Specimens are deposited in the National Museum of Natural History, Smithsonian Institution (USNM). Terminology and methods of morphological analysis are of Hershler (1998) and Hershler & Ponder (1998). Measurements of shells of the holotype and a series of paratypes are in Table 1.

SYSTEMATICS

Pyrgulopsis ***bruesi*** Hershler & Sada, sp. nov.

Type material: The holotype (USNM 892079) is a dried shell (2.55 mm shell length, Figure 1) from a small stream which enters Fly Reservoir, about 23 airline-km north-northeast of Gerlach, Washoe County, Nevada, T. 34 N., R. 23 E., SE ¼ section 2, elevation about 1238 m; collected by R. Hershler and D. W. Sada, 19 July 1997. Paratypes (USNM 860868) consist of a large series of dry shells and alcohol-preserved specimens collected from the type locality at the same time. Two additional series (USNM 892075, 892584), which are not designated as paratypes, were collected at the type locality by D. W. Sada at other times in 1997.

Diagnosis: A medium-sized species with ovate-conic shell having weakly rounded whorls. Penis small, narrow bladelike; filament medium length, lobe and penial glands absent.

Description: Shell (Figure 2A–C) ovate-conic, almost pupiform, width/height, 49–58%; height, 2.02–3.03 mm; width, 1.13–1.74 mm; whorls, 4.5–5.25. Protoconch near planispiral, 1.4 whorls, diameter about 300 µm, earliest 0.5 whorl slightly wrinkled, otherwise smooth (Figure 2D–F). Teleoconch whorls weakly convex or nearly flat (earlier whorls somewhat more rounded), sometimes narrowly shouldered, basal portion sometimes strongly an-

Table 1

Morphometric and meristic shell features of holotype and ranges of values for 10 paratypes of *Pyrgulopsis **bruesi***, new species. Morphometric parameters are expressed in mm.

	Holotype	Paratypes
Shell height	2.55	2.38–2.75
Shell width	1.47	1.19–1.47
Body whorl height	1.82	1.56–1.90
Body whorl width	1.27	1.15–1.41
Aperture height	0.99	0.85–1.07
Aperture width	0.87	0.82–0.93
Shell width/shell height	0.57	0.49–0.58
Number of whorls	4.75	4.75–5.25

Figure 1

Holotype of *Pyrgulopsis **bruesi*** Hershler & Sada, sp. nov., from Fly Hot Springs, Washoe County, Nevada.

gled; sometimes loosened for 0.25 whorl behind aperture. Aperture ovate, broadly adnate or slightly disjunct. Inner lip complete, slightly thickened; columellar lip sometimes slightly reflected. Outer lip thin, orthocline or weakly prosocline, sometimes weakly sinuate. Umbilicus narrow. Periostracum tan. Shells of males narrower, with flatter whorls, and slightly smaller than those of females.

Operculum (Figure 2G–I) thin, light amber throughout or colored only in attachment region, ovate, multispiral, nucleus eccentric. Edges of whorls frilled on outer surface (Figure 2G, H), sometimes markedly so; outer margin sometimes having weak rim. Attachment scar margin strongly thickened between nucleus and inner edge (Figure 2I), sometimes thickened all around.

Buccal mass medium-sized; radular sac extending behind buccal mass as small loop. Radula about 530 × 80 μm, with 55–60 rows of teeth. Central teeth (Figure 3A, B) trapezoidal, about 18.6 μm wide, dorsal edge well indented; lateral cusps 4–6; central cusp medium width, proximal edges parallel, distal portion pointed; basal cusp 1, large. Basal tongue broad V-shaped, basal sockets deep. Lateral teeth (Figure 3C) with 2–3 cusps on inner side and 3–5 cusps on outer side, central cusp rather broad; neck weakly flexed; outer wing length 200% width of tooth face. Inner marginal teeth (Figure 3D) with 21–27 cusps, outer marginal teeth (Figure 3E, F) with 23–27 cusps. Style sac about as long as remainder of stomach; stomach with small posterior caecum.

Cephalic tentacles usually unpigmented, sometimes pigmented with a few black granules proximally. Snout unpigmented. Foot usually unpigmented, sometimes pigmented with scattered black granules dorsally. Opercular lobe black along inner edge. Neck variably pigmented with black granules. Pallial roof, visceral coil lightly pigmented to near black, pigment lighter on genital duct than elsewhere. Males usually with darker pigment on mantle roof and visceral coil than females. Filament of penis almost uniformly pigmented with internal black granules, granules scattered proximally along length of penial duct.

Dorsal and ventral surfaces of tentacles bearing single longitudinal ciliary tracts. Distal penis bearing scattered long cilia near terminus, otherwise unciliated.

Ctenidium well developed; filaments 18–20, with pleats, broadly triangular, apices centrally positioned; ctenidium abutting pericardium posteriorly. Osphradium rather long, intermediate width, near centrally positioned. Renal gland longitudinal; kidney with small pallial bulge, opening slightly thickened. Rectum near straight, broadly overlapping pallial oviduct, abutting prostate gland.

Ovary 0.75 whorl, filling less than 50% of digestive gland behind stomach, abutting posterior edge of stomach. Albumen gland (Ag) having substantial pallial com-

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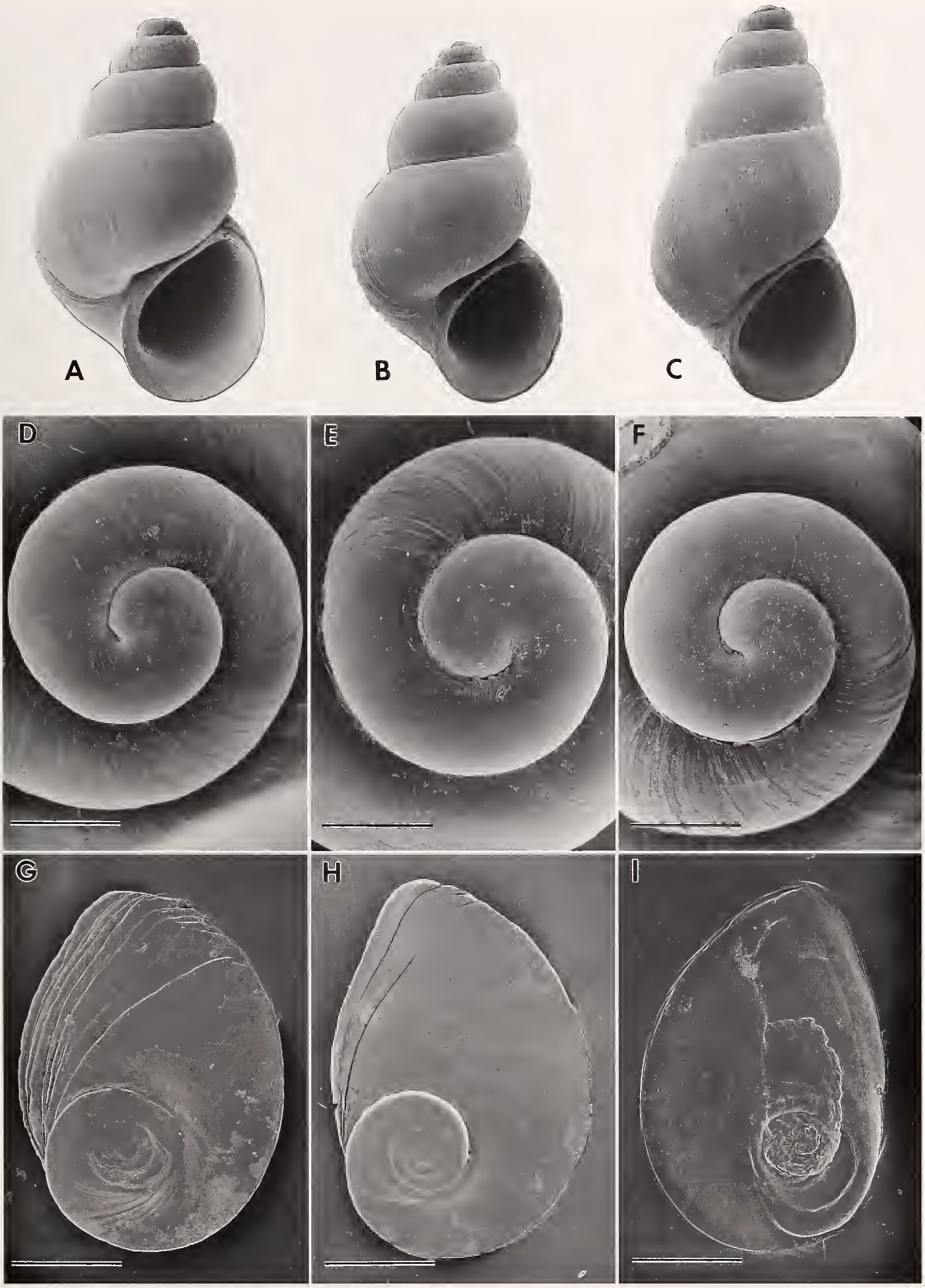
Figure 2

Scanning electron micrographs of shell and opercula of *P. **bruesi*** Hershler & Sada, sp. nov. USNM 860868. A–C. Variation in shell shape (shell height, 2.58 mm, 2.43 mm, 2.68 mm, respectively). D–F. Shell apices, showing weak protoconch sculpture (bars = 120 μm). G, H. Outer surface of operculum (bars = 240 μm, 200 μm, respectively). I. Inner surface of operculum, showing thickened border of muscle attachment area near nucleus (bar = 240 μm).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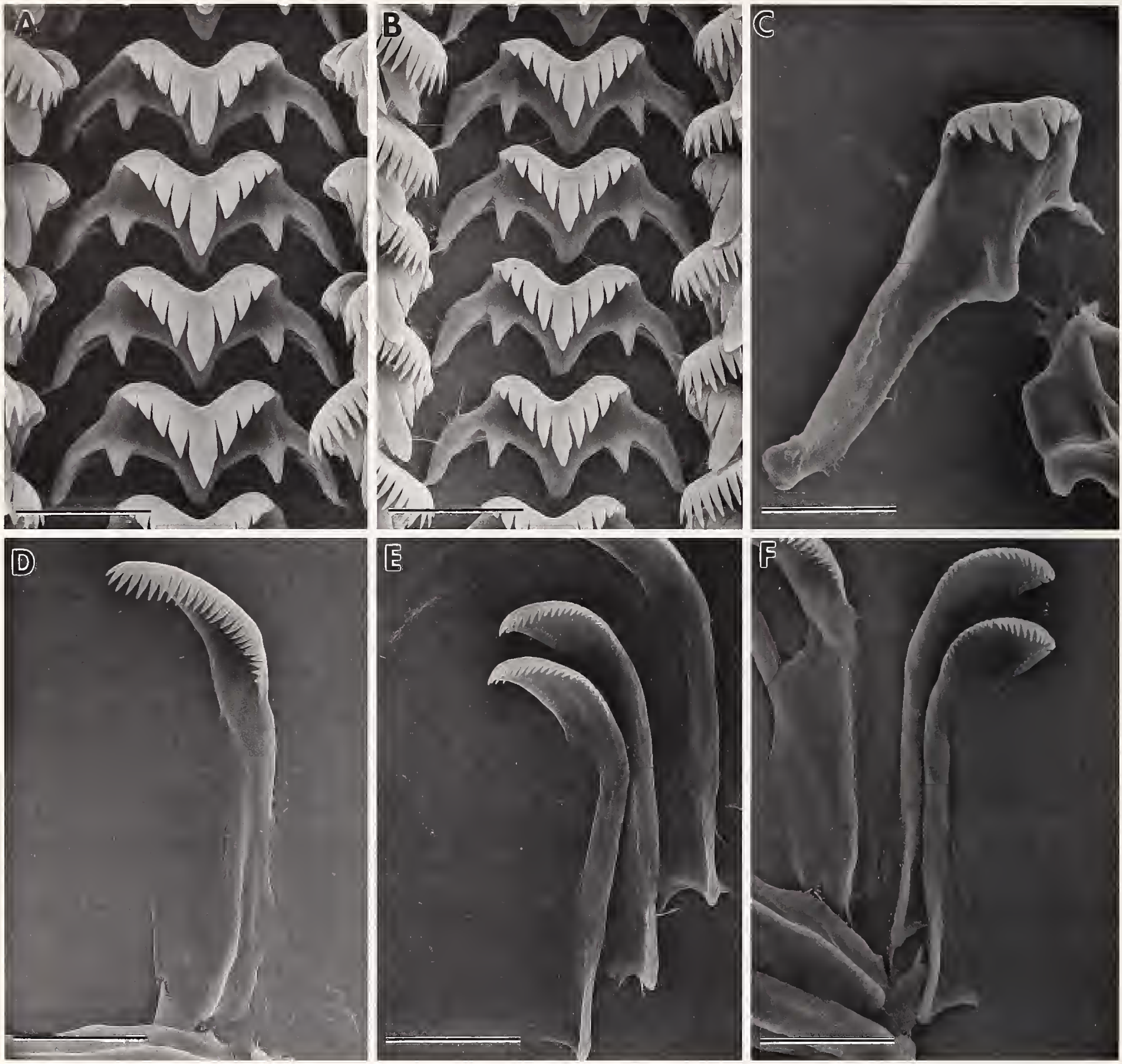

Figure 3

Scanning electron micrographs of radula of *P. **bruesi*** Hershler & Sada, sp. nov. USNM 860868. A, B. Central radular teeth (bars = 9.2 μm, 10.9 μm, respectively). C. Lateral tooth (bar = 10.9 μm). D. Inner marginal tooth (bar = 12.0 μm). E, F. Outer marginal teeth (bars = 12.0 μm).

ponent (Figure 4A). Capsule gland (Cg) slightly shorter, about as wide as albumen gland, divided into two equal-sized tissue sections (anterior, clear; posterior, white), broadly ovate in section, right lobe thicker than left; rectal furrow absent. Ventral channel (Vc) broadly overlapping capsule gland; longitudinal fold well developed. Genital aperture (Ga) a long terminal slit. Coiled oviduct (Cov) of two overlapping posterior-oblique loops. Oviduct and bursal duct joining just behind pallial wall. Bursa copulatrix (Bu) small relative to albumen gland, narrow or ovate, longitudinal, up to 50% of length posterior to albumen gland. Bursal duct originating from anterior edge at midline, slightly longer than bursa copulatrix, narrow or medium width (Figure 4B). Seminal receptacle (Sr) small relative to bursa copulatrix, ovate, positioned along ventral edge of distal oviduct coil and usually just anterior

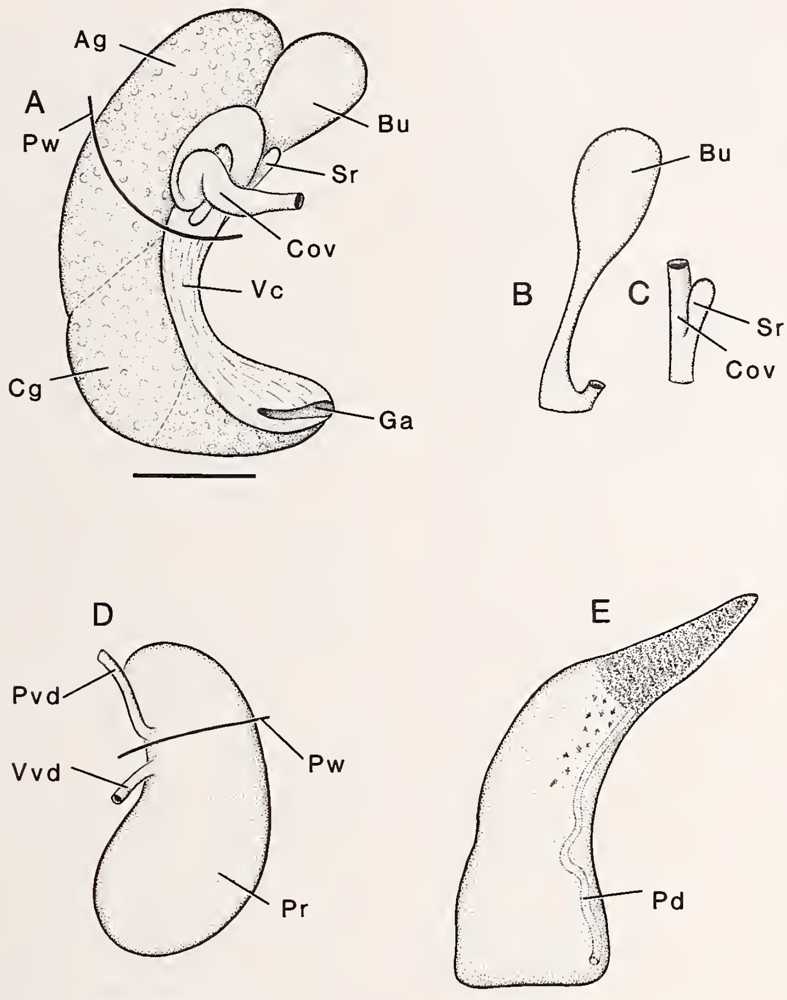

Figure 4

Genitalia of *P. bruesi* Hershler & Sada, sp. nov. USNM 860868. A. Left side of female glandular oviduct and associated structures. B. Bursa copulatrix and its duct. C. Seminal receptacle and its duct. D. Left side of prostate gland, showing insertion of vas deferens. E. Penis. Bars = 0.25 mm. Ag = albumen gland, Bu = bursa copulatrix, Cg = capsule gland, Cov = coiled oviduct, Ga = genital aperture, Pd = penial duct, Pvd = pallial vas deferens, Pr = prostate gland, Pw = posterior wall of pallial cavity, Sr = seminal receptacle, Vc = ventral channel of capsule gland, Vvd = visceral vas deferens.

to bursa copulatrix, duct slightly shorter than body (Figure 4C).

Testis 1.5–2.0 whorls, composed of numerous compound lobes, filling about 50% of digestive gland behind stomach, broadly overlapping stomach anteriorly. Seminal vesicle a medium-sized mass of tight coils opening from and positioned alongside the anterior portion of testis. Prostate gland (Pr) small, bean-shaped, pallial portion about 33% of total length, narrowly ovate in section (Figure 4D). Visceral vas deferens (Vvd) opening to ventral edge of prostate gland just behind pallial wall. Pallial vas deferens (Pvd) opening to ventral edge of prostate gland just in front of posterior wall; duct having distinct proximal bend on columellar muscle. Penis small; base elongate-rectangular, smooth; filament about 33% length of base, gently tapering, distally pointed, rather broad, longitudinal, poorly distinguished from base (apart from darker pigmentation); lobe and glands absent (Figure 4E). Penial duct (Pd) near inner edge, narrow, undulating a few times near base, otherwise near straight.

Etymology: A patronym, named after the late Charles Thomas Brues II (1879–1955) who, in addition to his notable studies in entomology (Mallis, 1971), surveyed thermal springs of the western United States (Brues, 1928, 1932) and brought the interesting biota of these habitats to the attention of the biological community. Brues (1932:206) early visited the type locality area ("sixteen miles northwest of Gerlach"), although he did not collect any snails. We propose the vernacular name, "Fly Ranch pyrg," for this species in reference to its type locality.

Comparisons: *Pyrgulopsis* ***bruesi*** and a small group of congeners share a simple penis without lobe or glands. Among these, *P.* ***bruesi*** is most similar to *P. augustae* Hershler, 1998, which lives about 190 km to the southeast (Antelope Valley, Lander County), but differs on the basis of its higher-spired shell (compare Figure 2A–C with Hershler, 1998:fig. 9B), larger penial filament (compare Figure 4E with Hershler, 1998:fig. 40A), and more ventrally positioned seminal receptacle (compare Figure 4A with Hershler, 1998:fig. 40B). These two species, together with another congener from the Great Basin of Nevada (*P. dixensis* Hershler, 1998) having a simple penis, are united by their narrow shell and distinctive thickening of the operculum attachment region border near the nucleus.

Habitat: The Fly Ranch Hot Springs is the largest spring zone in northwest Nevada (Garside & Schilling, 1979), consisting of about 40 sources (Grose & Keller, 1975) that collectively discharge about 500 acre-feet/year (= 0.69 cfs) (Sinclair, 1962). Thermal sources are located on a large mound and discharge into a series of pools, with drainage ultimately entering the Fly Reservoir (Figure 5). This hot spring area has been modified by surface water diversion, groundwater mining, dredging, and recreational activity.

Pyrgulopsis ***bruesi*** was collected from a turbid, 1 m deep and 1.5 m wide stream (Figure 6) fed by natural springs and a flowing well whose effluents have given rise to an impressive, three-pronged travertine tower (a second, similarly active tower, slightly north of the above, was figured by Sinclair, 1962:fig. 1; and Garside & Schilling, 1979:74). Water quality data obtained from this stream on 20 September 1997 are as follows: water temperature, 27.0°C; conductivity, 1760 mhos/cm; pH; 8.2; and dissolved oxygen content, 6.7. Snails were collected from submerged unidentified aquatic vegetation on which they were moderately abundant; fewer specimens were found on Cattail (*Typha*). Although considerably cooled relative to the boiling effluent of the well, this stream nonetheless ranks as a regional thermal water body as variously defined (e.g., Waring, 1965:4; Garside & Schilling, 1979:1). Another hydrobiid snail, *Tryonia protea,* which is broadly distributed in western North America (Hershler, 1999); pulmonate gastropods, *Helisoma anceps* and *Physella virgata,* and an unidentified amphipod were collected in association with *P.* ***bruesi***. The tui chub, *Gila bicolor,* also is present in this stream (Brues, 1932).

Distribution: This species is thus far known only from its type locality. During the course of our field survey, other sites in the Hualapai Flat basin were searched and did not yield this snail, although a congener, *P. gibba,* was collected from the flanking Granite Range (Hershler, 1998).

DISCUSSION

Pyrgulopsis has occupied habitats of the northern Great Basin since at least the late Miocene (Hershler & Sada, in press), and several scenarios for the origin of *P.* ***bruesi*** may be conjectured. Hualapai Flat is a small (about 200 km^2), endorheic, north-south trending graben bounded to the west by the imposing Granite Range. The Calico Hills form a lower hydrographic barrier to the northeast, while to the southeast Hualapai Flat is separated from the Black Rock Desert by an alluvial divide of only about 30 m (Sinclair, 1962). Thick Quaternary deposits on the floor of Hualapai Flat include fine sections attributable to Lake Lahontan, which also left sedimentary exposures elsewhere in the basin (Grose & Sperandio, 1978). Highstand elevations of Lake Lahontan (from Mifflin & Wheat, 1971) imply that the Fly Hot Springs area was flooded by a > 100 m deep embayment during the late Pleistocene. Evolution of *P.* ***bruesi*** may be attributable to isolation in basinal spring habitats coincident with the final recession of Lake Lahontan about 13,000 ybp.

Pyrgulopsis ***bruesi*** is one of many congeners that are endemic to flowing thermal waters. Experimental data indicates that while these snails actively prefer thermal habitats, they can tolerate considerably lower water temperatures (Mladenka, 1992). Invasion of Hualapai Flat from elsewhere in the Lahontan basin via dispersal within pluvial waters may thus be tenable for progenitors of *P.* ***bruesi***. Congeners that are most similar morphologically to *P.* ***bruesi*** also live within (*P. augustae*) or adjacent to (*P. dixensis*) the Lahontan basin, supporting a hypothesis that these were all derived from a widespread pluvial progenitor. Note that recently acquired evidence of high elevation early Pleistocene shorelines (about 1400 m) in the Lahontan basin implies that Dixie Valley (which harbors *P. dixensis*) may have been integrated with this regional drainage (Reheis, 1996; Reheis & Morrison, 1997), instead of containing an isolated pluvial lake as traditionally viewed (Mifflin & Wheat, 1979).

Alternatively, one may attribute less importance to pluvial dispersal of snails and postulate an earlier (pre-Pleistocene) origin of *P.* ***bruesi*** coincident with regional development of the modern basin and range landscape. Topographic closure of Hualapi Flat during the Neogene may be inferred by its location along the edge of the Black Rock-Carson Sink zone of extension, a tectonically active area of broad alluviated grabens whose youthful development involved extensive deformation of 17–6 ma extrusive igneous rocks (Wallace, 1984). On a local scale,

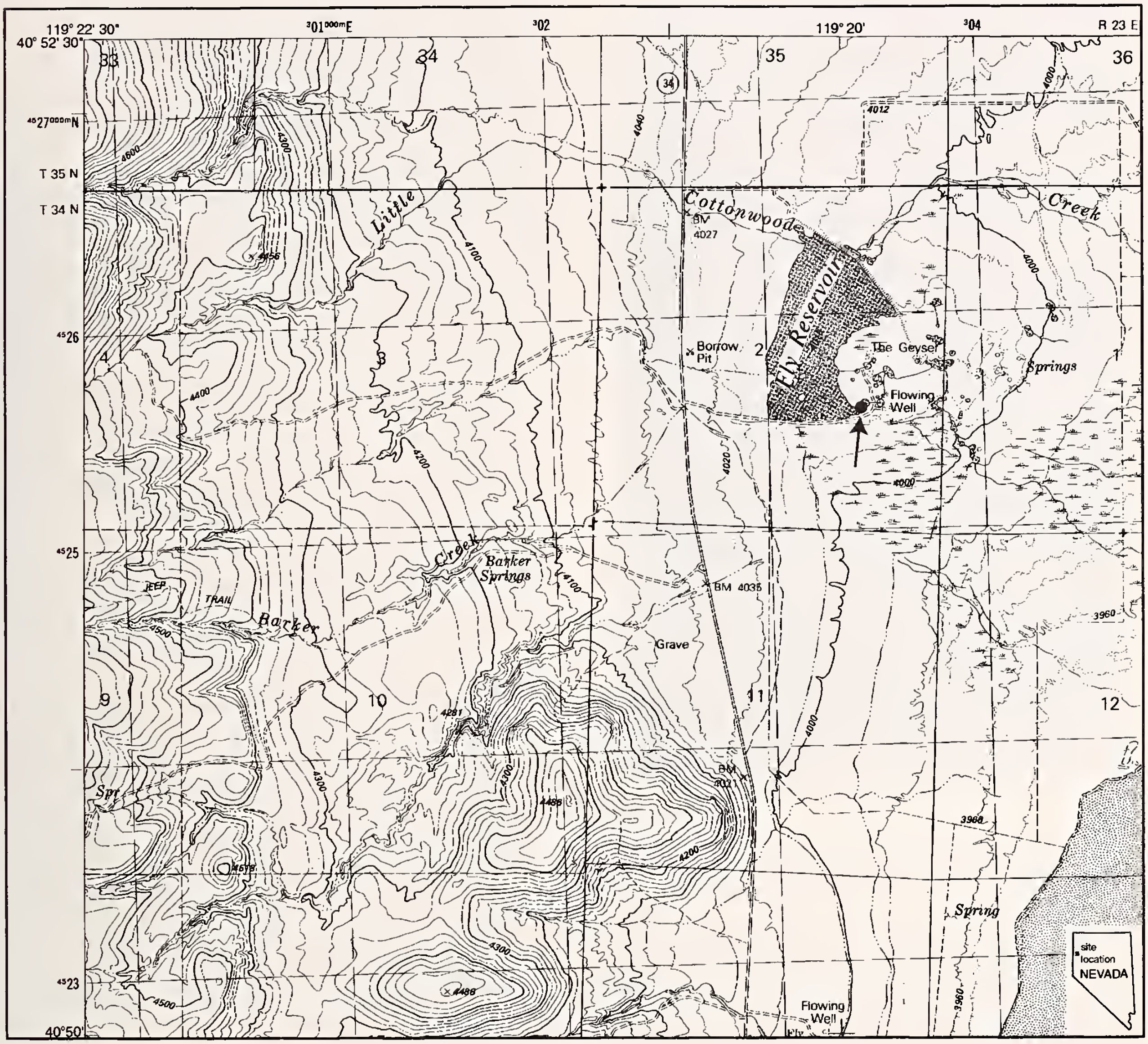

Figure 5

Location of type locality of *P. bruesi* Hershler & Sada, sp. nov. in Hualapai Flat (arrows). Map from USGS Hualapai Flat South Quadrangle, 7.5 minute series (topographic). Foothills of the Granite Range are to the west, and the edge of the Hualapai playa is to the southeast.

Hualapai Flat has been tectonically active from the late Cenozoic through the Holocene, with both normal and lateral slip along several major fault zones (Grose, 1978; Grose & Sperandio, 1978). Uplift of the Granite Range on the west side of the basin has been particularly rapid and extensive (Bonham, 1969; Grose, 1978). Hualapai Flat is bisected by a regional north-south fault zone which extends from the High Rock area to the Pyramid Lake basin (Grose, 1987). Occurrence of local hot spring activity is attributed to the intersection of this and another, northwest-trending fault zone, which permits deep penetration to a regional heat reservoir (Sperandio & Grose, 1976). (Near-surface intrusive bodies are not sufficiently hot to generate local geothermal activity.) Although individual springs in the Hualapai Flat may be no more than Lahontan in age, the supplying heat reservoir has been in place for 2–20 my (Grose, 1978) which, together with locally extensive faulting from mid-Tertiary into the Holocene, suggests that a long history of thermal spring activity in the area now occupied by this basin is feasible.

Figure 6

Type locality of *P. **bruesi*** Hershler & Sada, sp. nov. Granite Range is in the background. Photograph, 19 July 1997.

A pre-Pleistocene origin of *P. **bruesi*** requires persistence of this snail through the time period when Lake Lahontan flooded Hualapai Flat. Snails may have invaded basinal habitats from higher elevation springs (following desiccation of this lake) in conjunction with migrating geothermal activity as mediated by local faulting. (Fossil spring deposits attest to local migration of surface thermal activity; Grose, 1978.) The possibility that basinal springs harbored snails while covered by Lake Lahontan also merits consideration.

Acknowledgments. We thank Y. Villacampa for assistance with scanning electron microscopy, K. Darrow for inking anatomical drawings, M. Ryan for her drawing of the holotype and assembly of plates, and D. Cole for preparing the map (all from USNM). Fieldwork was supported, in part, by a 1997 award from the National Museum of Natural History Biological Surveys and Inventories Program (BSI).

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